Full versus limited vibration diagnostics

Analysis using all the tools available is much more powerful than limiting diagnostics to a single tool such as spectrum analysis.

Normal

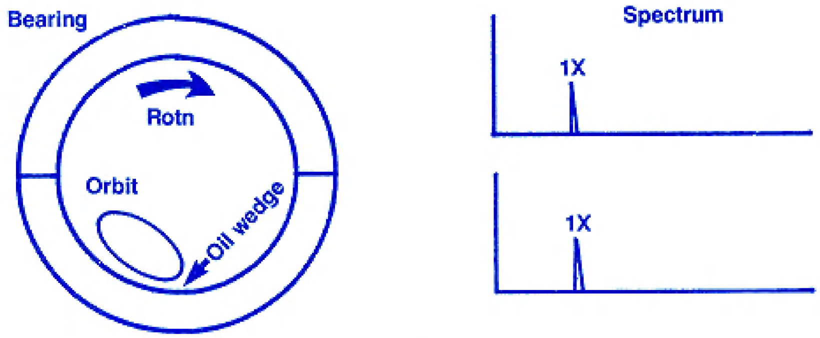

Figure 1

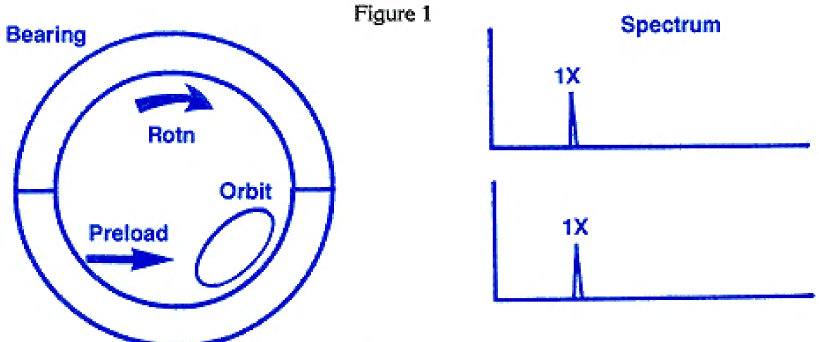

Figure 2

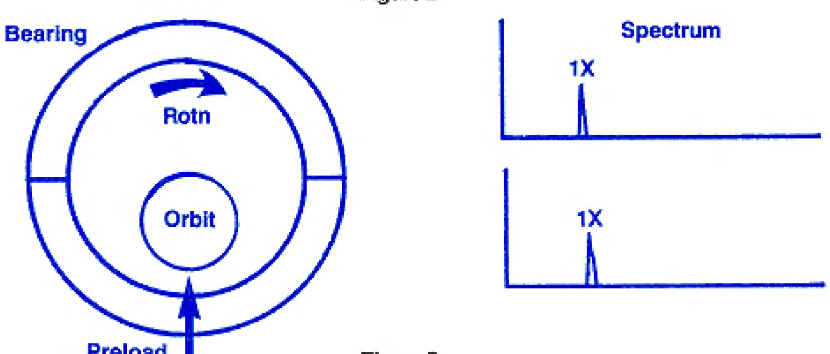

Figure 3

Whenever possible, a diagnostician should use all the tools available to analyze a problem. Quite often, the vibration diagnostician does not take advantage of all the information available. A full "tool kit" for the rotating equipment specialist should include:

- **Amplitude** - Indicates the severity of the problem
- **Frequency** - Helps classify the source of the problem
- **Phase** - Identifies the direction of vibration
- **Form (usually Orbits)** - Shows the rotor motion
- **Position** - Shows the rotor relative to the bearings

Specialists often limit themselves to amplitude and frequency, even when other information is available! Before proximity probes were developed, many machines were originally monitored using casing-mounted transducers, usually with only a single transducer per machine. Amplitude and frequency analysis, commonly called Spectrum analysis, was the only tool available. As more machines were monitored using proximity transducers in the XY configuration, phase, form, and position analysis became both available and appropriate.

Before a machine problem can be resolved, there are three questions that must be answered:

1. What should the machine normally do?
2. What is the machine doing now?
3. What could cause the machine to respond in such an abnormal manner?

When observing only amplitude and frequency, a machine is often consid-►

ered to be operating normally if the majority of the vibration is at the running speed of the machine (1X). The availability of form and position information makes it easier to determine what is normal. Figure 1 illustrates how, if a machine has a clockwise rotating rotor and sleeve bearings, an oil wedge will form on the right side of the rotor, forcing it upwards and to the left. Due to gravity and assuming a horizontal machine, the rotor will move horizontally more freely than vertically. By looking at where it will be positioned inside the bearing, one can see why the motion is predominantly in a plane 45° to the left of vertical in this case.

Although the vibration is predominantly 1X, merely looking at frequency would provide only limited information. For illustration, consider what the machine is doing now and what could cause the machine to respond in such an abnormal manner (questions 2 and 3) for some common malfunctions:

Unbalance

If rotor unbalance increases, the frequency line representing the 1X vibration should increase. In the Orbit format, the Orbit should increase in size, but the overall orientation should not change.

Horizontal preload

If the rotor is pushed to the right by an outside force and forced to ride against the right side of the bearing, the Orbit will tilt to the right instead of tilting to the left (Figure 2). This is significantly different. It is very possible, when using a spectrum, that there would be no difference at all! Were there a change, it would either increase the 1X vibration, in which case it would be diagnosed as unbalance, or the 1X could decrease, in which case it would be considered a better-operating machine.

Vertical preload

Application of an upward preload to the rotor would also affect the data. Again, because of the effects of gravity, vertical vibration should be less than horizontal vibration. Applying just enough upward preload to counteract gravity would produce an Orbit where the vibration in the horizontal and vertical directions is equal (Figure 3). Frequency data would still predominantly display 1X vibration.

Frequency data alone does not provide information about the dynamic path of the rotor centerline. Orbits, which display this path and the direction of the Orbits (forward or reverse of shaft rotation), provide a powerful tool for analysis of problems.

While there are some malfunctions that show up well in frequency data alone, they will show up more clearly using the full tool kit of amplitude, frequency, phase, form, and position. ■

ProbeTip

The importance of *Not 1X* vibration

Once the proper transducers and monitors are installed to monitor a machine, operators often ask, **"The monitor is indicating high vibration levels, what should I do?"**

Instantaneous increases almost always call for an immediate change in machine operation and a call for assistance. Gradual increases in vibration often make decisions more difficult.

In some plants, the first step for the operators is to always call in a rotating equipment specialist to analyze the vibrations. However, in most plants a specialist may not be immediately available. Often consultants cannot be used unless the magnitude of the problem justifies the expense.

Fortunately, some simple diagnostics work can quickly determine the severity of the problem and the level of urgency needed for a more detailed analysis. The operator can compare the portion of the vibration signal that is synchronous, 1X, to the portion that is nonsynchronous, *Not 1X*.

A large proportion of machinery vibration problems, possibly as many as 50 percent, cause a change in 1X vibration. More than forty faults that cause changes in 1X vibration have been identified. However, most changes are due to changes in the balance state of the rotor. Gradual changes in 1X vibration need to be analyzed but generally do not require an immediate change in machine operation or an urgent call for a specialist.

The *Not 1X* portion of the overall vibration is often a strong indicator of malfunctions that can quickly be detrimental to the machine. Some of the most common causes of *Not 1X* vibration are fluid induced instabilities, rotor to static part rubs, and gear faults. All are of immediate concern.

Therefore, when overall vibration increases, the operator should examine the *Not 1X* portion. If there has been an increase, a specialist should be consulted to determine the root cause of the increase. ■